EXTRUDED PLASTIC SCINTILLATOR

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International Scoping Study – Detector Session
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THE EARLY WORK: 1995-1998

DISADVANTAGE FOR LARGE DETECTORS

- Expensive: price of cast scintillator ~ $40/kg
  - MINOS uses 300,000 kg of scintillator!

➔OBJECTIVE:

USE LOW COST SCINTILLATOR

➔APPROACH:

NEW TECHNIQUE → EXTRUSION

PLASTIC SCINTILLATORS: PREPARATION

CAST SCINTILLATORS: PLATES, TILES, FIBERS

- Purification of styrene monomer
  - Removal of inhibitor
  - Vacuum distillation
- Addition of dopants
- Thermal polymerization
  - No initiators
  - Freeze-pump-thaw cycle
  - Temperature cycle to control average molecular weight

EXTRUDED PLASTIC SCINTILLATOR

ADVANTAGES:

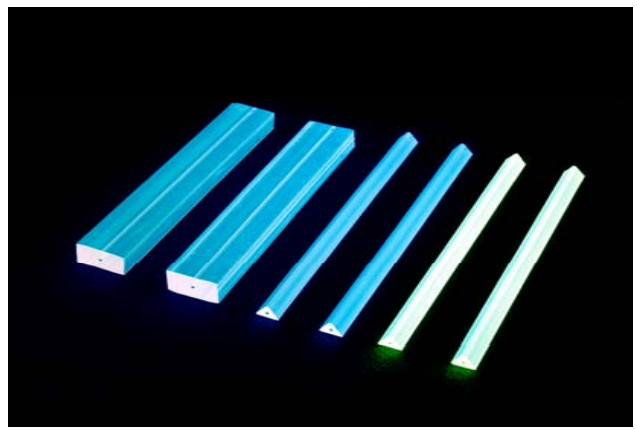
- Use commercial polystyrene (PS) pellets
  - No monomer purification problems
- Processing flexibility
  - Manufacture of essentially any shape

DISADVANTAGES:

- Poorer optical quality
  - Particulate matter in PS pellets
  - Additives in PS pellets

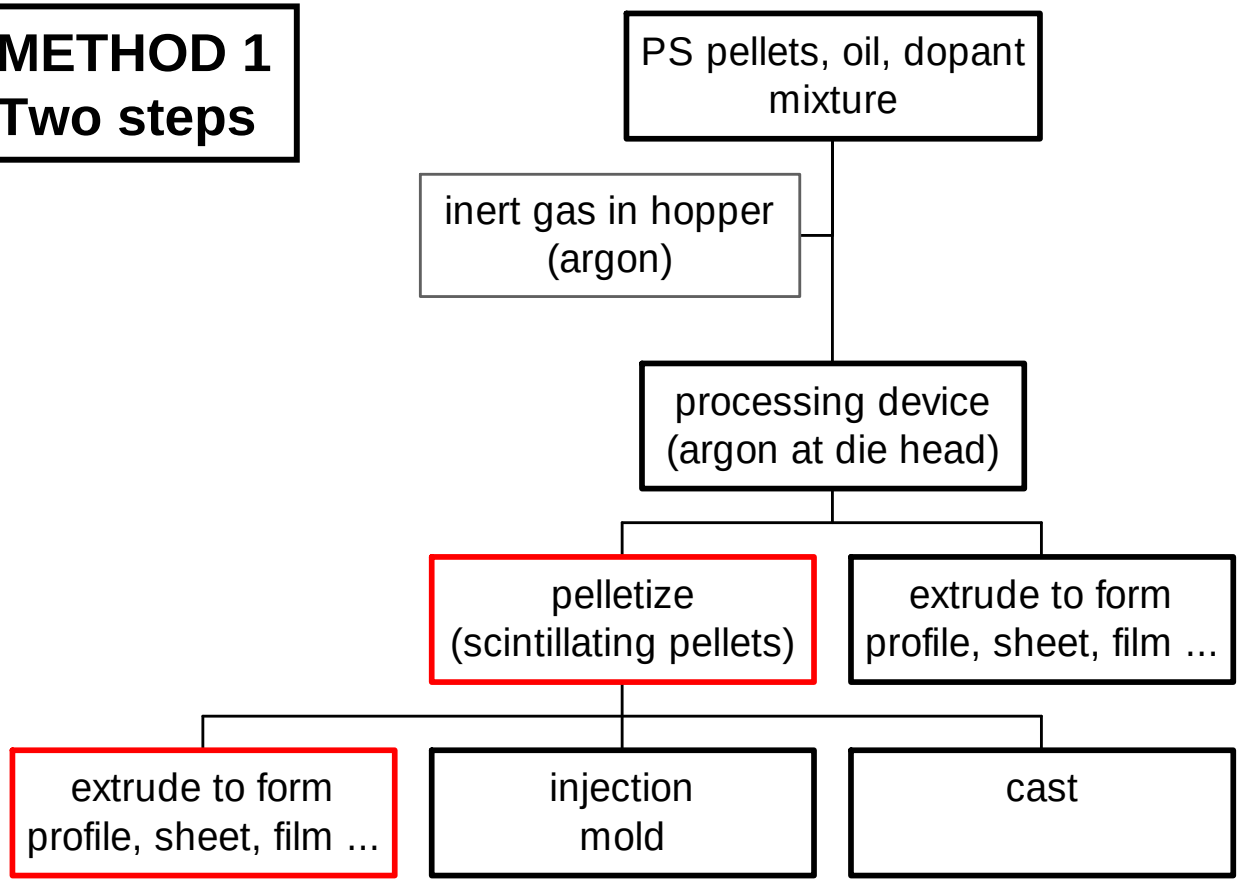
SOLUTION:

- **Use a WLS fiber**



MANUFACTURING TECHNIQUES: D0 – PRESHOWER DETECTORS

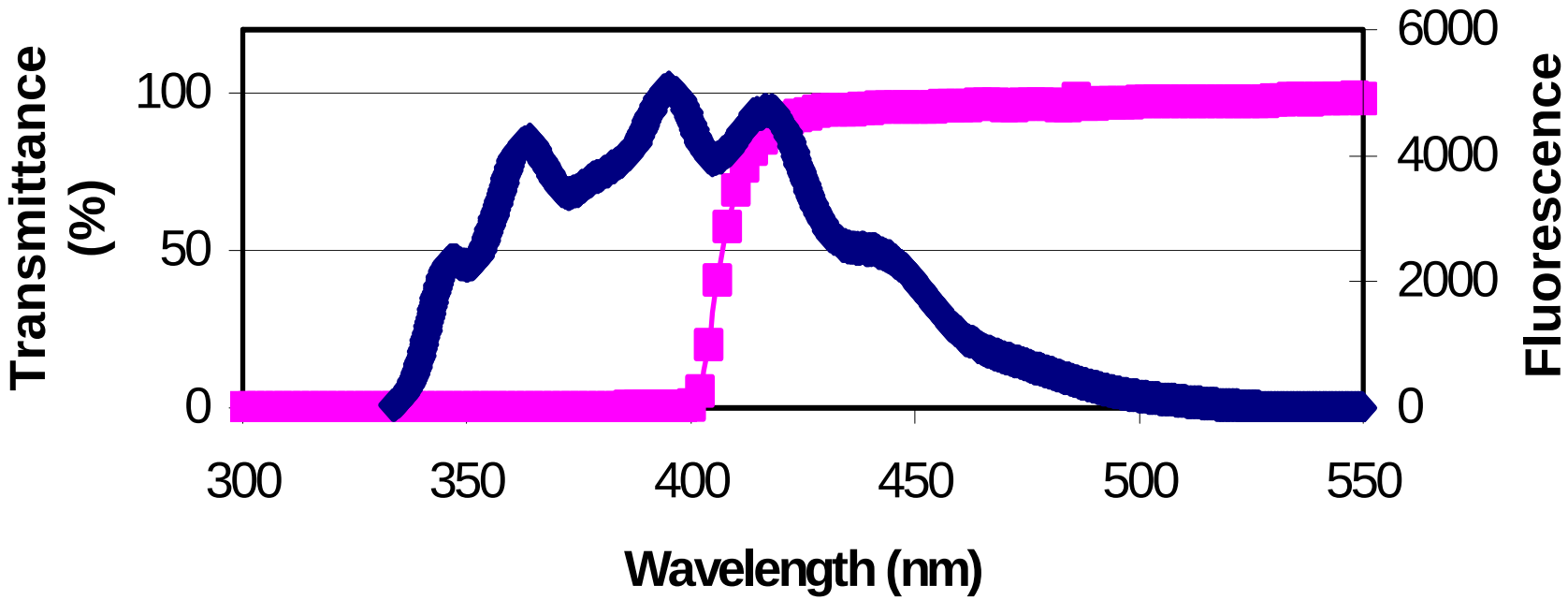
METHOD 1
Two steps



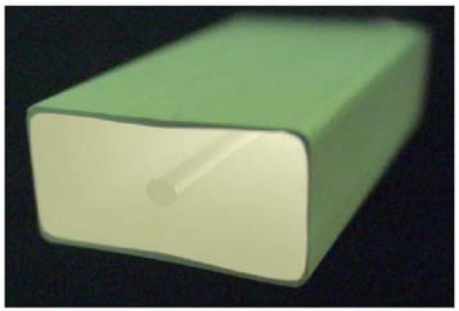
EXTRUDED SCINTILLATOR COMPOSITION

Polystyrene: Dow Styron 663 W

1% PPO + 0.03% POPOP



MANUFACTURING TECHNIQUES: MINOS, STAR, K2K… 1999 – STILL USED



METHOD 2

Batch process

One step

polystyrene pellets

dopants

MIXER

Container to purge mixture with nitrogen

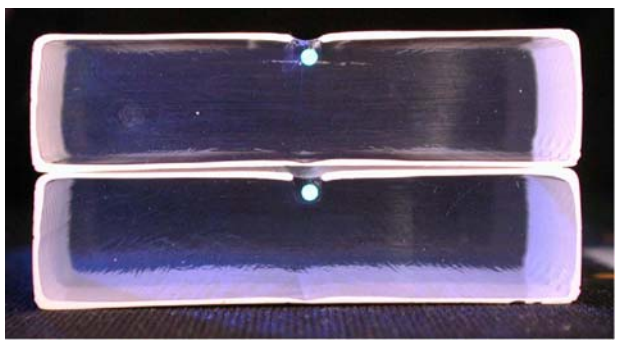
titanium dioxide mixture

EXTRUDER (64-mm single screw)

CO-EXTRUDER (32-mm single screw)

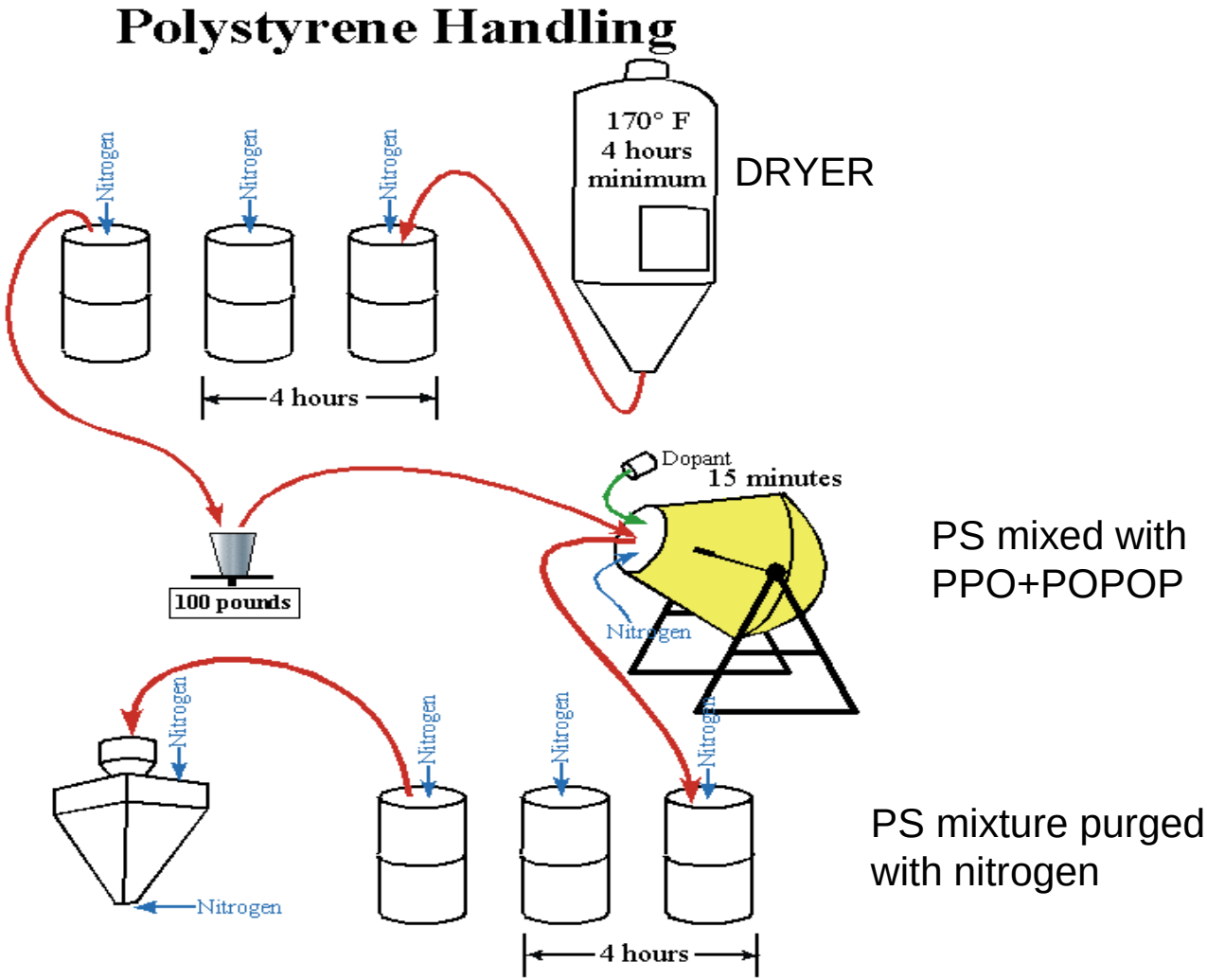
DIE

Scintillator strip with white reflector coating



EXTRUSION AT ITASCA PLASTICS: PURGING STAGE, BATCH PRODUCTION

Dry PS purged with nitrogen



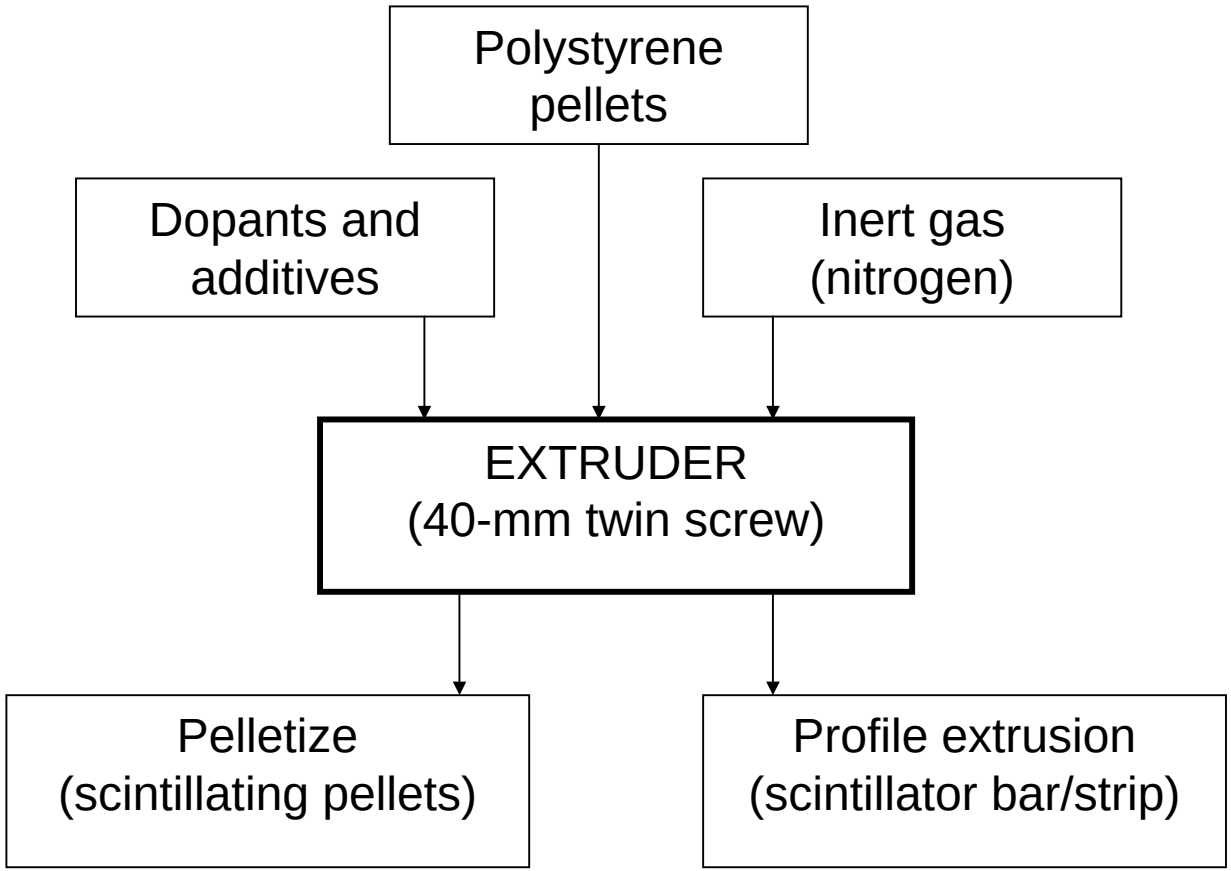
PS mixed with PPO+POPOP

Hopper purged with nitrogen

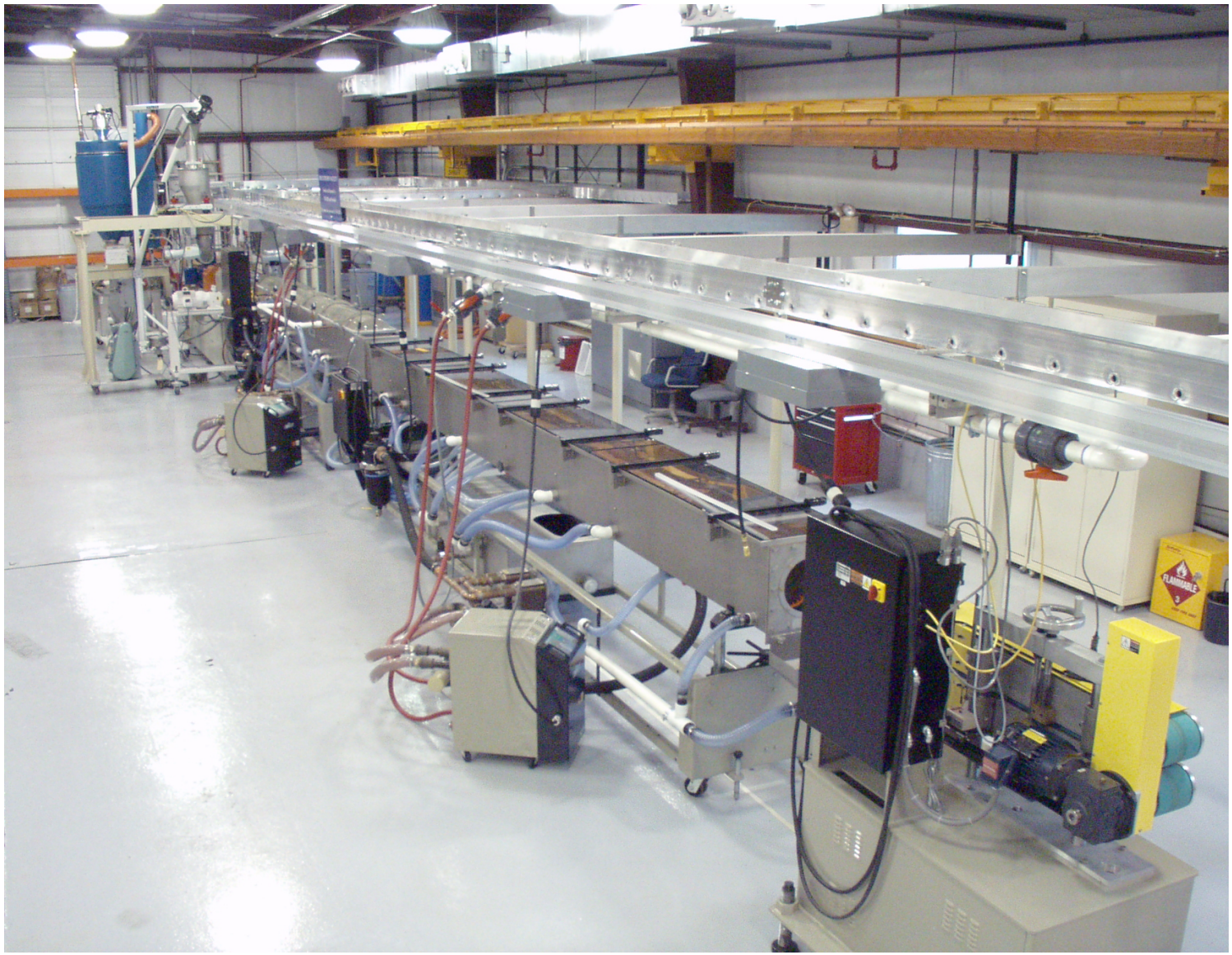
PS mixture purged with nitrogen

EXTRUSION AT ITASCA PLASTICS: PURGING STAGE, BATCH PRODUCTION

WORK IN PARALLEL SINCE 1999: IN-LINE EXTRUSION



FNAL-NICADD EXTRUSION FACILITY



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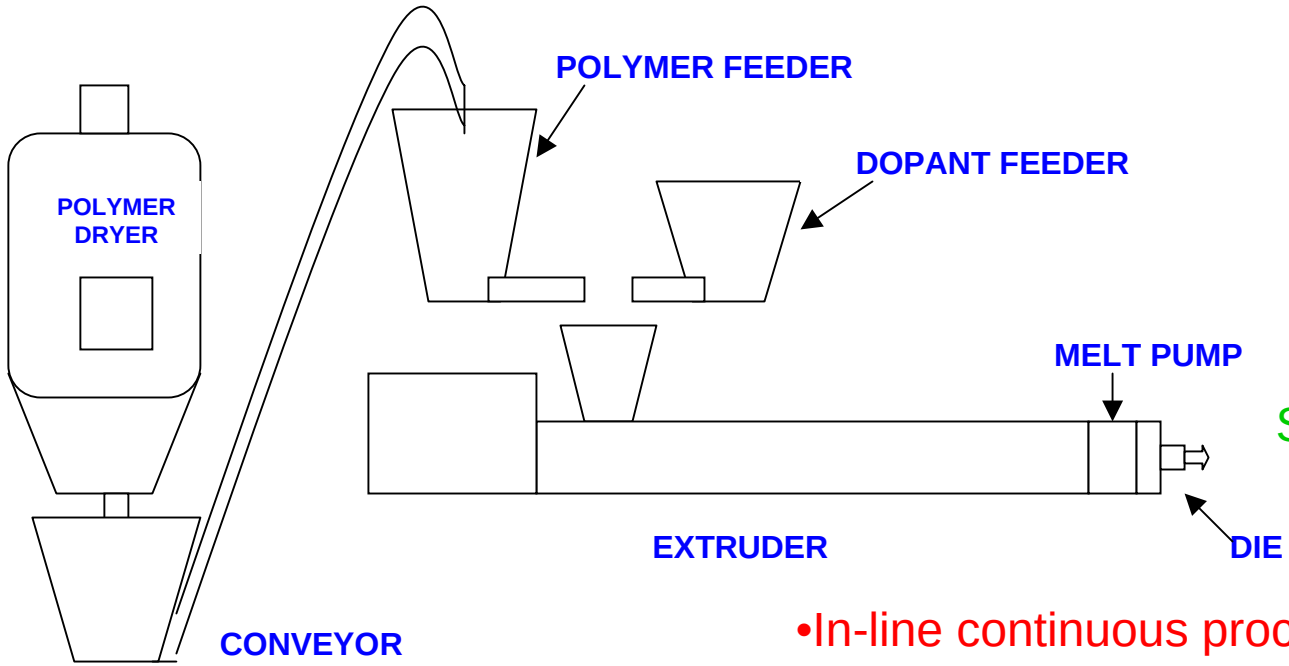


OUTPUT:

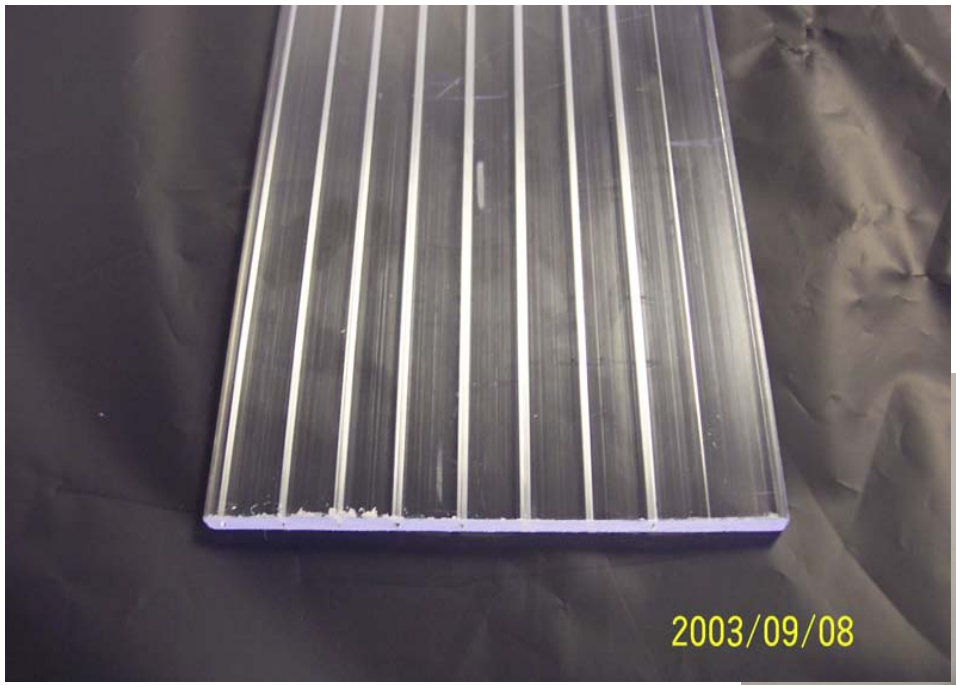
Scintillating pellets
Scintillator bars

- In-line continuous process:
  - Less handling of raw materials
  - Precise metering of feeders
  - Twin-screw extruder (better mixing)
  - Melt pump offers steady output
  - Control instrumentation

- Line under nitrogen atmosphere:
  - Drying under nitrogen
  - Each piece of equipment is purged

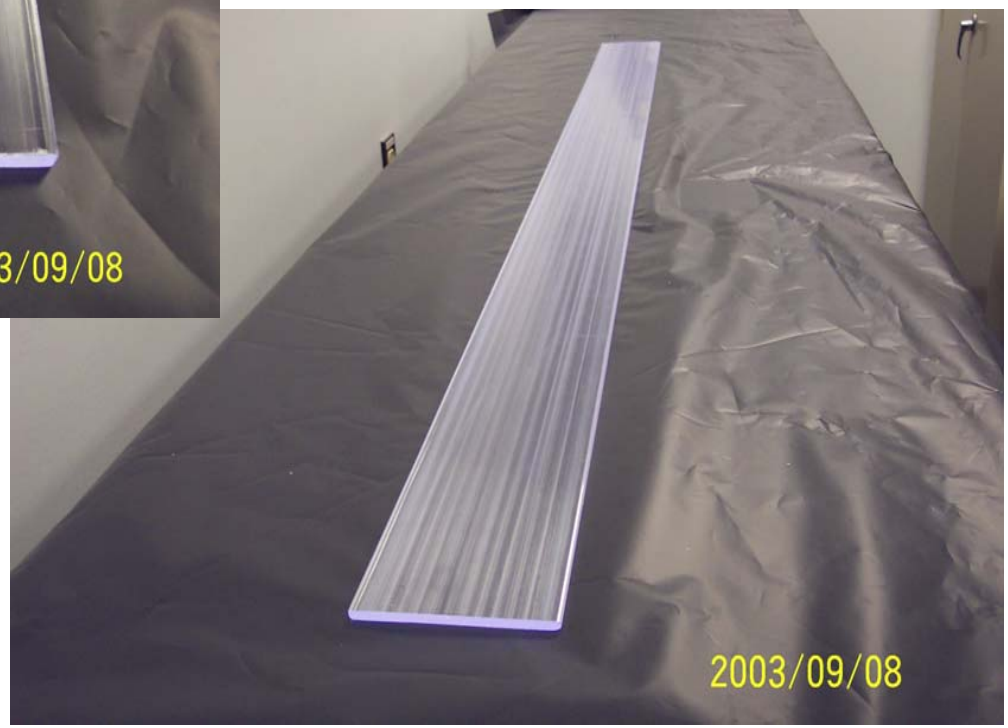
FNAL-NICADD EXTRUSION FACILITY: CO-EXTRUDER – OCTOBER 2005

FNAL-NICADD EXTRUSION FACILITY



0.5 cm x 10 cm strips

10 holes, 1 mm diameter



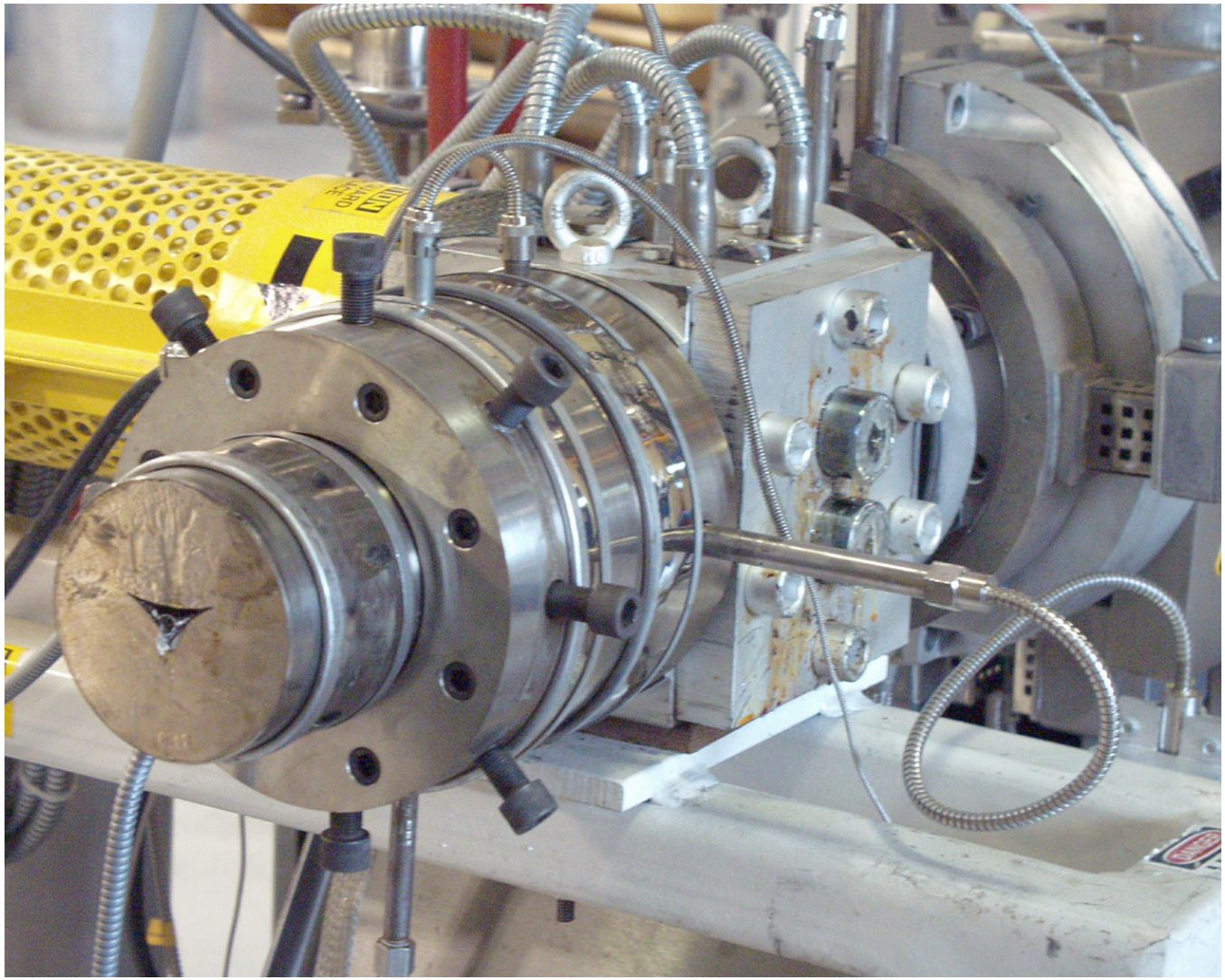
solid

4.87 ± 0.03 mm

20 cm intervals

44 m total

FNAL/NICADD EXTRUSION FACILITY: DIE FOR MINERVA – 2005



EXTRUDED SCINTILLATOR: COSTS

- MINOS (~300 tons): about $10 / kg
- Recent projects (0.3 ton): about $25 / kg
- Estimated projection for large quantities: $6 – 7 / kg

- Early extrusion efforts showed the cost at roughly:
  - 50% materials, 50% processing

- ADVANTAGE of in-line method:
  - Higher extrusion rate 75 –100 kg / h, lower processing costs
  - More consistent scintillator, less QC efforts, lower processing costs
- ADVANTAGE of high volume production:
  - Lower price for raw materials

EXTRUDED PLASTIC SCINTILLATOR: NEAR FUTURE

- A lot of progress has been made.
- Extrusion efforts:
  - FNAL/NICADD Facility
  - Triumf – Canada (R&D for KOPIO)
  - Kyungpook National University – Korea (R&D Linear Collider)
  - Inquiries from University of Udine – Italy (R&D Linear Collider)

- Improvements:
  - Prepare in-line QC of scintillator
  - Study and test new dies designed with Computational Fluid Dynamics simulations
  - Coating reflectivity